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Ferroelectricity Newsletter

A quarterly update on what's happening in the field of ferroelectricity

Volume 2, Number 2 Spring 1994

IN THIS ISSUE

WILL 1994 BECOME A BANNER YEAR IN THE ANNALS OF FERROELECTRICITY?

In the last issue of the ***Ferroelectricity Newsletter*** we started to present a broad picture of the history and the future of ferroelectrics research. Our goal during the course of this year is to keep filling in details in order to gain a better understanding of the direction this area of investigation is taking.

Dr. Rainer Bruchhaus from Siemens Corporate Research and Development in Munich has taken time out of his busy schedule to provide an **overview of research activities in the area of ferroelectric thin films in Germany**, a field that in his opinion has not received the same attention as in the United States. You will find his report identifying the key participants and their main areas of investigation on page 5.

A project whose primary objective is to demonstrate the feasibility of making ferroelectric films of high-density, nonvolatile memory quality and to integrate them with existing CMOS technologies, is coordinated by Dr. Poul K. Larsen from Philips Research Laboratories in Eindhoven and involves the **participation of several European countries**. An interesting fact connected with this research effort, which Dr. Larsen describes in his article ***Ferroelectric Layers for Memory Applications and Sensors*** on page 6, is the way information is handled between different industrial participants without violating confidentiality.

In an effort to shrink the time it takes for research results to reach the ferroelectrics community, we are reprinting -- the abstract in one case and the text minus figures and references in the other -- two papers delivered at the ISSCC in February introducing the new **Matsushita/Symetrix memory**. (See LATE BREAKING NEWS on pages 2 to 4.)

With the same purpose in mind, we bring you titles and authors of the **papers to be given at the ISIF 94 in March**. From now on we will try to publish lists of papers presented at major ferroelectrics conferences closer to the time they are actually delivered. We hope this will facilitate a more timely exchange of information and we ask conference organizers for assistance in this endeavor.

Rudolf Panholzer
Editor-in-Chief

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ISIF 94 PAPERS

The following is a list of titles and authors of papers delivered at the ***6th International Symposium on Integrated Ferroelectrics,*** *held from 14 to 16 March 1994 at Monterey, California.*

The **Proceedings of ISIF 94** *will be published in the journal* **Integrated Ferroelectrics**. *We will let you know the date of publication.*

A. MEMORY RELATED TOPICS

1. Applications and Devices at Component Level

256 Kbit Nonvolatile Memory
T. Sumi;

BST Capacitor Technology for GaAs MMIC Applications
D. Ueda;

Ferroelectric Gate Transistors
T. Tabson et al;

Characteristics of NDRO Ferroelectric Memory Device With Sol-Gel PZT Thin Films
T. Nakamura et al;

Preparation of $Bi_4Ti_3O_{12}$ Films by MOCVD and Their Application to Memory Devices
T. Nakamura et al;

SPICE Simulation of Memory Cell Circuitry Using an Improved Ferroelectric Capacitor Macro Model
D.E. Dunn and J.D. Monroe;

Mechanisms for the Operation of Thin Film Transistors on Ferroelectrics
C.H. Seager et al;

Determining the Fist-Band Voltage of a Metal-Ferroelectric-Semiconductor Device by Collection of Alpha Particle Impact Ionization Charge
E. B. Smith and T. A. Rabson;

A Study of Gradual Reversal of Polarization in Ferroelectric PZT Thin Films for Adaptive-Learning MFSFET Applications
N. Tanisake et al;

A Ferroelectric Superconducting Photo-Transistor
H. Lin et al;

A Feasibility Study for Nondestructive Readout Ferroelectric Memory Device
H. Yoshimori et al;

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LATE BREAKING NEWS

UPDATE ON NONVOLATILE MEMORY TECHNOLOGY

As reported on page 2 of theWinter 1994 issue of the Ferroelectricity Newsletter, *two papers introducing new ferroelectric devices were presented on 18 February 1994 at the International Solid State Circuits Conference in San Francisco. We are reprinting the abstract of the first article and the text of the second article minus figures and references.*

256Kb Ferroelectric Nonvolatile Memory Technology for 1T/1C Cell with 100ns Read/Write Time at 3V

T. Sumi, N. Moriwaki, G. Nakane, T. Nakakuma, Y. Judai, Y. Uemoto, Y. Nagano, S. -I. Hayashi, M. Azuma, T. Otsuki, and G. Kano (Matsushita Electronics Corporation, Kyoto); *L. McMillan and C. Paz de Araujo* (Symetrix Corporation, Colorado Springs, CO)

A ferroelectric nonvolatile memory is much superior to other nonvolatile memories, such as EEPROM, in terms of data transfer rate, fatigue and other characteristics. The ferroelectric RAM is expected to be very useful not only for memory devices but also as a nonvolatile memory on microcontroller chips. One of the issues for 3V operation of a conventional 1T/1C cell derives from a reference cell configuration. Read difference voltage at a bit line pair is impaired by a built-in voltage remaining at a reference cell capacitor after restore procedure of logic "L." The issue is resolved by a preset reference cell circuit that guarantees 0V on the reference cell capacitor.

In order to polarize the ferroelectric capacitor, a cell plate must be pulsed, which results in an increase in current consumption. Therefore, to reduce the parasitic capacitance of the cell plate, a divided cell plate configuration, comprising a global cell plate line and local cell plate lines, is employed. Only a local cell plate line is connected to the global cell plate line, thus reducing the parasitic capacitance to 1/4.4 and current consumption by 0.4mA at a cycle time of 200ns at 3V.

The 256Kb ferroelectric RAM is fabricated in 1.2um process with single aluminum interconnection. The ferroelectric material is the so-called "Y-1." Spin-on-coat method and ion-milling are used for the capacitor formation.

The ferroelectric RAM has almost no fatigue after 10^{12} destructive read and rewrite stress cycles and its retention time is more than 10 years at 70 C.

Applications of Integrated Ferroelectric Technology

W. I. Kinney and F. D. Gealy (Micron Semiconductor Inc., Boise, ID)

There has been a recent upsurge of activity regarding the integration of ferroelectric capacitors with ICs. This renewed interest is driven, in part, by the potential use of ferroelectric (or paraelectric) thin films as the dielectric in the storage capacitors of 1Gb density DRAMs. The high relative permittivity of these thin films permits smaller DRAM capacitors and simpler fabrication sequences than standard oxide/nitride dielectrics. In addition,

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NONVOLATILE MEMORY TECHNOLOGY -- continued from page 2

recent advances in the reliability of ferroelectric thin films are causing renewed interest in the use of ferroelectric capacitors as storage elements in nonvolatile memories. Such memories have several potential advantages over current nonvolatile technologies. Ferroelectric memories have write times in the order of 100ns in contrast to 10µs for FLASH. Ferroelectric memories should endure over 10^{12}write cycles compared to 10^5 cycles for current FLASH, and ferroelectric capacitors can be programmed at 5V rather than voltages of 10V to 20V required in floating gate memories.

The materials $PbZr_xTi_{1-x}O_3$ (PZT), $BaTiO_3$, and $Ba_xSr_{1-x}TiO_3$ (BST) are typical of the ferroelectric thin films used for integrated capacitors. Above the Curie temperature, the materials act as dielectrics having high relative permittivity. The Sr and Ba concentration of BST can be adjusted so that the Curie point is below room temperature, and the relative permittivity is about 300. This material is a primary candidate for use in 1Gb DRAM storage capacitors. On the other hand, at temperatures below the Curie point, ferroelectric materials distort to a noncentrosymmetric crystal phase exhibiting stable, spontaneous electric polarization. The orientation of this polarization changes in response to an applied voltage larger than the coercive voltage and leads to a charge/voltage hysteresis loop, like that of Figure 1. In nonvolatile applications, data is represented by the different orientations of this spontaneous polarization.

The schematic for a destructively read nonvolatile ferroelectric memory cell is shown in Figure 2. This cell is similar to that of a DRAM with an additional plateline (PL) control. The READ operation of this cell is shown schematically in Figure 3. During a PL pulse, the charge on the capacitor plates changes by a large amount if the polarization orientation switches (denoted as a "1" state) and by a smaller amount if it does not switch (denoted as a "0" state). As in a DRAM, a sense amp detects the resulting BL voltage, latches, and restores the original data. The bitline-to-cell capacitance ratio determines the size of the signal on BL. A ratio that is too large causes a BL voltage that is too small to reliably sense. In contrast to a DRAM, however, a ratio that is too small also reduces the signal by reducing the voltage drop across the ferroelectric, reducing the amount of polarization switching. Ferroelectric design is further complicated by large variations in the total switched charge when the temperature changes. Thus a large range of bitline-to-cell capacitance ratio will occur during operation. Furthermore, the BL signal from a "0" state, which should ideally be 0V, is often too large to be ignored. This substantially complicates the design of a reference voltage for the senseamps. Despite these complications, however, the initial characteristics of existing ferroelectric materials provide sufficient margin to design a nonvolatile part with density and performance similar to current DRAM.

Despite the potential advantages of integrated ferroelectric capacitors, only a few devices are commercially available. Ferroelectric materials

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2. Device Processing and Integration

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Effects of Process Integration and Electrodes on Performance of PZT Ferroelectric Memories
R. Nasby and T.A. Hill;

Ferroelectric Integration: Progress and Challenges
M. Huffman and L. McMillan;

Processing and Performance of Integrated Ferroelectric and CMOS Test Structures for Memory Applications
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Influence of Ti and TiO_X Interfacial Layers on the Electrical and Microstructural Properties of Sol-Gel Prepared PZT Films
C.J. Rawn et al;

Effects of Furnace and RTA Annealing of the Top Platinum Electrodes on Sputtered and Sol-Gel Derived PZT Film Capacitors
B.J. Rod et al;

Passivation of Ferroelectric PZT Capacitors Using Spin-On-Glass
J.R. Schifko et al;

Rapid Thermal Processing of Sol-Gel Perovskite Thin Films
M. Sedlar et al;

Stoichiometric Vapor Deposition of Ferroelectrics from Volatile Double Alkoxide Precursors
R. Xu et al;

Chemical Vapor Deposition of $PbLaTiO_3$
P.C. Van Buskirk et al;

Preparation of PZT Thin Films by MOCVD Using a New Pb Precursor
M. Shimizu et al;

Spatially Uniform Lead Perovskite Thin Films Formed by MOCVD
H. Miki et al;

3. Materials Processing

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Deposition of Transparent and Electroconductive Chalcogenide Films at Near-Room Temperatures
I. Grozddanov et al;

Investigation of Hillock Formation on Platinized Silicon and their Effect on PZT Capacitor Performance
E.A. Kneer et al;

Microwave Annealling and Investigation of Ferroelectric Films
Y. M. Poplavko et al;

PE-MOCVD and Sol-Gel Processing Science of High Permittivity Dielectric Thin Films
C.K. Barlingay et al;

Preparation of Strontium Titanate Films by MOCVD
A. Gill et al;

Deposition of $LiTaO_3$ Thin Films on Single Crystal Substrates by Vapor Phase Hydrolysis of Volatile $LiTa(OC_4H9)_6$ Precursor
K.W. Chour and R. Xu

Plasma-Enhanced MOCVD Processing of $SrTiO_3$ and $Ba_{1-x}Sr_xTiO_3$ Thin Films
C.S. Chern et al;

Process Optimization of MOCVD BST for Advanced DRAM
S. Barbee et al;

Growth and Electrical Properties of $Ba_{0.7}Sr_{0.3}TiO_3$ Thin Films by LSCVD in a 6-Inch Single Wafer Reactor
S. Hayashi et al;

4. Device Characterization and Reliability

Low-Voltage Ferroelectric Nonvolatile Memory Technology: Device and Reliability Issues
R. Moazzami;

Characterization of PZT Films Grown by MOCVD on a 6-8 Inch Si Wafer
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Pulse Switching Characterization of PZT Thin Films for High Density Memory Applications
D.J. Taylor;

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LATE BREAKING NEWS

NONVOLATILE MEMORY TECHNOLOGY -- continued from page 3

exhibit nonideal behavior, and IC processing often degrades them further. The switchable polarization decreases during nonvolatile memory operation and results in poor endurance and retention. "Fatigue" limits the memory's write endurance by causing a reduction of signal during repeated polarization switching. A ferroelectric nonvolatile memory using destructive readout is particularly prone to fatigue since polarization switching may occur during each read operation. Attempts to avoid this endurance issue by using devices capable of nondestructive readout have so far met with limited success. Ferroelectric memories also suffer from retention failure caused by polarization "aging" and "imprint." Aging causes the polarization to freeze in one direction so that it does not respond to read operation. Imprint causes the polarization to gradually return to a different, previously written orientation. All three of these effects (fatigue, aging, and imprint) cause a reduction of the BL signal from a "1" state. In addition, imprint causes an increase of the signal from a "0" state. These long-term reliability problems have so far prevented the realization of viable nonvolatile memories with densities comparable to present DRAM devices.

Recent breakthroughs in thin film ferroelectric capacitors have essentially eliminated fatigue and have dramatically improved aging and imprint. When deposited on specially prepared conducting oxide electrodes, PZT takes on a preferred crystallographic orientation and exhibits substantially improved characteristics. The proprietary ferroelectric material referred to as "Y-1" shows excellent properties when used with standard polycrystalline Pt electrodes. Figures 4 and 5 illustrate the stability of switchable polarization in these materials.

The mechanism leading to the improved properties in these new ferroelectric thin film structures are not yet understood. However, sufficient empirical data is now becoming available to justify renewed efforts in nonvolatile ferroelectric memories. The key challenges of these efforts will be associated with producing small-area capacitors, fully integrated on packaged ICs, which maintain these improved properties. □

CORRECTION

On page 2 of the Winter 1994 issue of the ***Ferroelectricity Newsletter*** there is an error in the article *Cooperation Between Matsushita and Symetrix Produces New Ferroelectric Devices.*

The last paragraph should read:

Symetrix announces that their room temperature LSCVD equipment achieves BST with leakage below 10^{-10}A/cm^2, dielectric density over 95 ƒF/μ^2 with high breakdown voltage at 400Å.

The dielectric density was erroneously given as **30ƒF/μ^2.**

RESEARCH IN EUROPE

RESEARCH ON FERROELECTRIC THIN FILMS IN GERMANY

In Germany there is a long tradition on research and development of ferroelectric materials. In the past the interest has concentrated mainly on materials in bulk ceramic form. Recently, worldwide strong interest has focused on the deposition of ferroelectrics in thin film form and its integration with microelectronic devices for a variety of possible applications. This interest has triggered the activities in Germany in the field of ferroelectric thin films. Research laboratories of industrial companies and institutes have started to deposit and investigate these films for application in nonvolatile ferroelectric memory devices, as dielectric in future generations of DRAMs, pyroelectric IR detectors, and other applications. The activities are mainly concentrated at the **Philips Research Laboratories in Aachen,** at the **Rheinisch Westfälische Technische Hochshule (RWTH) Aachen**, the **Fraunhofer Institut in Würzburg**, the **Corporate Research and Development of Siemens in Munich**, and the **Institut für Neue Materialien in Saarbrücken.**

The **Philips group** uses the sol-gel process to deposit perovskite films including lead zirconate titanate (PZT), $BaTiO_3$ and $SrTiO_3$ with and without doping. Film formation as well as the influence of different type and concentration of dopants on the ferroelectric and dielectric properties have been extensively studied. PZT films will be used for nonvolatile ferroelectric memory devices.

The group at the **RWTH Aachen** investigates the dc electrical conduction and breakdown of perovskite type titanate films. Based on thorough defect chemistry studies the contribution of the bulk and the electrode interfaces to the electrical conduction has been calculated. The results are very important for the application of these films in devices and their long term stability.

At the **Fraunhofer Institut in Würzburg** a specially designed sol-gel process for PZT has been developed. With that process crack free films of abut 1µm thickness using only one coating step can be deposited. Thus, the repeated coating and drying commonly used in the spin on-process can be avoided. This specially designed processing opens for the spin-on technology those applications in which thicker ferroelectric films are needed.

The **Siemens group** is concentrating on the sputtering of ferroelectric films. A planar multi target approach is used to deposit films of the PZT materials family. The advantage of the multi target sputtering method is that the film stoichiometry can be varied simply by changing the electrical power on the targets. Lead titanate and PZT films with different Zr/Ti ratio have been deposited. Lead titanate films are investigated for their possible use in pyroelectric detectors.

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High Temperature Oxygen Environment Barrier Metal Process
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Fatigue and Photoresponse of Lead Zirconate Titanate Thin Film Capacitors
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Partial Clamping Influence in Integrated Ferroelectric Film Properties
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Effects of Optical Irradiation on the Fatigue Behavior of Lead Zirconate Titanate
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Polarization Fatigue Characteristics of Sol-Gel Ferroelectric $Pb(Zr_{0.4}Ti_{0.6})O_3$ Thin Films
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The Effects of Bipolar Pulsed Fatiguing on the CV Characteristics of PZT and Y-1 Discrete Capacitors
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The Degradation of Ferroelectric Properties of PZT Thin Films due to Plasma Damage
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Fatigue, Coercive Field and Built-In Electric Field Assisted Nucleation in Ferroelectric Thin Films
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Accelerated Retention and Stability Test of Y-1 Ferroelectric Material
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Electrical Characteristics of $(Ba,Sr)TiO_3$ Thin Films Developed by Physical Vapor and Chemical Growth Processes
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Imprint Mechanisms in PZT Thin Films
I.K. Yoo and S.B. Desu;

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Pulsed Laser Deposition of Ferroelectric Thin Films
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In-Situ Deposition of PZT Thin Films by RF Magnetron Sputtering
P.H. Ansari and A. Safari;

Characterization of $LiNbO_3$ Thin Films Grown on Al_2O_3 by RF Sputtering
F. Armani-Leplingard et al;

Preparation and Characterization of Lead Zirconate Titanate Thin Films by DC-Reactive Co-Sputtering
N.-H. Cho and H.-G. Kim;

Control of Electrical Properties of Ion Beam Sputter-Deposited PZT-Based Layered Heterostructures
K.D. Gifford et al;

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W.-J. Lee and H.-G. Kim;

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RESEARCH IN EUROPE

FERROELECTRIC LAYERS FOR MEMORY APPLICATIONS AND SENSORS (FELMAS)

The European Union (EU), formerly the European Economic Community, supports precompetitive efforts between industrial, governmental, and university partners. Such efforts divide risks and costs and can combine the strong points of the different partners thus leading to large synergy and rapid progress. In 1989-90 it was clear that the efforts within Europe in the area of ferroelectric thin films for memory applications were quite modest compared to notably the USA, and that Europe was falling behind in this potentially important technological field. The first attempts to obtain support from the EU for ferroelectric memory projects failed, but in 1991 the project FELMAS was supported in the framework of the ESPRIT program, Microelectronics Area. It should be noted that in general the rejection percentage of proposals is about 80 to 90 percent.

The FELMAS consortium consists of the industrial participants Philips (The Netherlands), acting as project coordinator, Thomson-CSF (France) and GEC (UK). Within Thomson-CSF and GEC the activities are divided between different subsidiary companies. Further participants are the two governmental laboratories IMEC (Belgium) and LETI (France) and the Laboratoire de Ceramic at EPFL (Switzerland). The funding from the EU for its members is 50 percent of their budget. The last partner is situated outside the EU and is funded by the Swiss Government.

The FELMAS project, having a duration of two years, was started in May 1992 with the primary objective to demonstrate the feasibility of making ferroelectric films of (high-density) nonvolatile memory quality and to integrate them with existing CMOS technologies. Thus the project includes all aspects of ferroelectric nonvolatile memories with mostly one partner assigned to a certain task.

During the first year the project concentrated on fundamental issues for making ferroelectric capacitors and on integration technologies. This includes electrodes, mainly Pt-based, barrier layers, and ferroelectric thin films of composition $Pb(ZrTi)O_3$ or PZT. The methods of sol-gel deposition and organometallic chemical vapor deposition are used for the preparation of the PZT films. These two methods have different thermal budgets and allow comparison of integration aspects. The integration technology (1.5 μm details) includes structuring of ferroelectric capacitors (FECAPs) and integration of ferroelectric and CMOS processing as well as contamination issues. Further the design of a test structure evaluation module (TSEM) was carried out during the first year. This TSEM contains a number of specific CMOS test modules (diodes, transistors, resistance structures, etc.), specific ferroelectric modules (FECAPs of various areas and shapes, resistance structures, etc.), simple memory cells, and a small memory of 256 bit. In addition, there are test structures to evaluate the properties of the ferroelectric films for sensor applications.

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Processing and testing of the TSEM are the main objectives in the second year. The first TSEM prototype has been produced and is giving encouraging results. But still a lot remains to be done and we shall continue our efforts until the end of the project around May-June of this year.

One important point for the outcome of a project like FELMAS is the way in which the exchange of information as well as the necessary flow of materials and test samples are ensured. Clearly, the project is based on a detailed technical plan describing the responsibility of each partner, but this is not enough. Firstly, all partners have access to the generated knowledge (handling it confidentially, of course). Secondly, regular meetings, about every three months, allow the participants to get to know each other and help exchange information and make decisions. Monthly written reports on ongoing work of each partner ensure fast updating of knowledge. Finally, perhaps most important for the outcome, is the willingness of the partners to consider each other as colleagues and not as competitors, i.e., to cooperate in a fair and decent manner.

Although the knowledge generated within FELMAS is in principle confidential, a considerable part has been or will be made available to the scientific community in the form of presentations and papers. In this way FELMAS contributes to the progress in the field of integrated ferroelectrics.

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FERROELECTRICITY PRODUCT WINS AWARD

Japan's largest newspaper, ***Nikkei Shimbun***, has given its **Product of the Year Award** to **Matsushita Electronics Corporation** for their **ferroelectric (BST) based microwave monolythic integrated circuits (MMICs).**

It is the first time in history that a ferroelectric product won the award.

For more information on the device, see the article ***Cooperation between Matsushita and Symetrix Produces New Ferroelectric Devices*** in the ***Ferroelectricity Newsletter***, Vol. 2, No. 1, page 2.

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Preparation of $(1_x)Pb(Mg_{1/3}Nb_{2/3})O_{3-x}PbTiO_3$ Thin Films by Pulsed Laser Deposition
C. Tantigate and A. Safari;

Pulsed Excimer Laser Ablation of Relaxor Type Perovskite Thin Films for Micro-Capacitor and High Permittivity Related Electronic Applications
S.B. Krupanidhi;

Pulsed Excimer Laser Ablation and Electrical Studies of $(Pb_{1-x}La_x)TiO_3$ Perovskite Thin Films for Electronic Applications
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Optimization of Sol-Gel Processing Conditions for PZT Thin Film Fabrication
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Sol-Gel Derived PZT Films for Non-volatile Memory Applications
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Sol-Gel Derived $BaTiO_3$ Thin Films
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Preparation of Epitaxial $KNbO_3$ Thin Films by Sol-Gel Technique
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Dielectric and Ferroelectric Properties of Acetate-Derived PBZT and PSZT Thin Films
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7. High Dielectric Constant Materials for ULSI DRAMs

The Characterization of Leakage Conduction in Ferroelectric PZT and BST Films for DRAMs
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Dielectric Properties of Doped $Ba_{0.7}Sr_{0.3}TiO_3$ Capacitors for DRAM Applications
B.M. Melnick et al;

The Preparation of $(Ba_{1-x},Sr_x)TiO_3$ Thin Film by Laser Ablation Technique and its Electrical Properties for 256 Mb DRAM Applications
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Pe-MOCVD Kinetics and Conformality of Dielectric Thin Films
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PLT(28) Thin Films with High Linear Dielectric Permittivity I: Microstructure Development and Schottky Barrier Formation
J.J. Lee and S.K. Dey;

PLT(28) Thin Films with High Linear Dielectric Permittivity II: Electrical Modeling and Leakage Current Mechanisms
J.J. Lee and S.K. Dey;

Characterization of a Spin-On 70/30 BST Process
B.M. Melnick et al;

Electron Cyclotron Resonance (ECR) Plasma Assisted Growth of $SrTiO_3$ Thin Films for DRAMS
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8. Characterization of Ferroelectric Materials and Microstructure

Microstructural Issues of Titanate/Substrate and Titanate/Electrode Interfaces
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Influence of Substrate Technology on Microstructural Development of $Pb(Zr,Ti)O_3$ Thin Films
B.A. Tuttle et al;

The Growth and Characterization of $SrTiO_3/BaTiO_3$ Multilayers
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Difference in Microstructure Between PZT Thin Films on Pt/Ti and Those on Pt
T. Hase et al;

Characterization of MOCVD BST Films by Spectroscopic Ellipsometry
J. Chapple-Sokel et al;

Deep Level Transient Spectroscopy Characterization of Sol-Gel Derived $Pb(Zr,Ti)O_3$ Thin Films
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Influence of Temperature and Crystallization Atmosphere on Electrical Parameters of Lead Zirconate Titanate Thin Films
G. Chiorboli et al;

Phase Transformations in Sol-Gel PZT Using Glancing Angle X-ray Diffraction
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Positron Annihilation Studies of Vacancy Related Defects in Ceramic and Thin Film PLZT Materials
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Time-of-Flight Pulsed Ion-Beam Surface Analysis as a Means of In-Situ, Real-Time Characterization of the Growth of Ferroelectric and Conductive Oxide Heterostructures
A.R. Krauss et al;

Scanning Force and Friction Microscopy (SFFM) of Ferroelectric $Pb(Zr,Ti)O_3$ Thin Films
M. Labardi et al;

Band Structure Effects in $Pb(Zr,Ti)O_3$
W.L. Warren et al;

Defect Compensation Mechanism and Time Dependent Electrical Properties of Donor Doped $Pb(ZrTi)O_3$ Thin Films
C.K. Barlingay et al;

Methods for Control of Perovskite PZT Nucleation on RuO_2 Electrodes and Their Effects on the Electrical Properties
H.N. Al-Shareef et al;

B. THEORY

Ferroelectric Phase Transitions: A First-Principles Approach
K.M. Rabe;

Metal Insulator Transition in Strongly Correlated Systems
M. Gulacsi and K.S. Bedell;

Defect Chemistry Model of Electrode/Ferroelectric Interfaces
C. Brennan;

Some Trends in Study of the Physical Nature of Perovskite High-Anisotropic Piezoelectric Ceramics
A.V. Turik et al;

Optical Nonlinear Effects of Thin Ferroelectric Films Near the Curie Point
A.S. Carrico;

The Effect of Thin Film Scalling on the Capacitance Versus Voltage Characteristics of a Ferroelectric Memory Cell
J.W. Gregory et al;

C. OPTICAL DEVICES AND APPLICATIONS

Hybrid Integrated Optical Devices Utilizing Thin Films of Lithium Niobate
C.H.-J. Huang and T.A. Rost;

Issues in Optical Characterization and Hybrid Integration of Ferroelectric Films
V.E. Wood;

The Effect of Microstructure and Composition on Optical Attenuation in Lithium Tantalate Films on Sapphire Grown by Chemical Beam Epitaxy
R. Bellman and R. Raj;

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Processing Thin Films of $KNbO_3$ for Optical Waveguides
T.M. Graettinger et al;
Oxide Thin Films for Ferroelectric Optical Waveguides
D.K. Fork et al;
Second Harmonic Generation in Optical Waveguides
S. Kurimura;
Optical Memories Using $(Pb,La)(Zr,Ti)O_3$ Films
D. Dimos et al;
Reversible Photovoltaic Currents from Paired PZT Film Capacitors with Semitransparent Electrodes
P.S. Brody and K.W. Bennett;
$BaTiO_3$ Thin Films for Optically Active Waveguides
B.A. Block and B.W. Wessels;
Effects of Laser Radiation on Photoconductivity in PZT Thin Films
L. Li et al;
Light Scattering from Thin $Pb(Zr,Ti)O_3$ Films
M.B. Sinclair et al;
Photo-Induced Effects in $BaTiO_3$ Dielectrics
W.L. Warren et al;

D. MICROSENSORS AND ACTUATORS

Processing of Sol-Gel Derived Ferroelectric for Microelectro-Mechanical Systems
L.F. Francis;
Silicon-Based Ultrasonic Microsensors and Micropumps
R.W. White;
The Use of Piezoelectric Actuators/Sensors for Intelligent Material Systems: An Application to Structural Modal Testing
C.A. Rogers;
Ferroelectric Thin Films for Microactuators
A.M. Flynn and K. R. Unayakumar;
Integrated Ferroelectric Microelectromechanical Systems (MEMS)
D.L. Polla;
Design and Fabrication of Thin Film Piezoelectric Actuators
D.A. Barrow et al;
PZT Films for Micropumps
K. Brooks et al;
Hybrid Ultrasonic Elastic Force Motors Micromachined in Silicon
G.-A. Racine et al;
Integrated Ferroelectric Pressure Sensor
K. Soorikaumar et al;

E. FERROELECTRIC SUPERCONDUCTOR PHENOMENA AND DEVICES

Interactions at Ferroelectric/Electrode Interfaces
S.B. Desu;
A Review of SFRAM Memory Technology
J.T. Evans;
Can the $YBa_2Cu_3O_7/SrTiO_3$ Layered Structure be Used for Design of Millimeter Wave Phase Shifters?
A.B. Kozyrev et al;
Fabrication and Testing of Micron-Scale $(La,Sr)CoO_3/(Pb,La)(Zr,Ti)O_3/(La,Sr)CoO_3$ Capacitors
J. Lee et al;
Microstructure and Superconductivity in Bi(Pb)SrCaCuO Oxide Ceramic
S.C. Mathur et al;
Dielectric Properties of (Pb-Bi-Sr-Ca-Cu-O) Ceramics in Normal and Superconducting States
S.C. Mathur et al;
Ferroelectric Properties of (Pb-Bi-Sr-Ca-Cu-O) Ceramics in Normal and Superconducting States
S.C. Mathur et al;
Broadband Phase Shifter Combining High Temperature Superconductors and Ferroelectric Thin Films
A. Kain et al;

F. MICROWAVE APPLICATIONS OF FERROELECTRICS

$Sr_xBa_{(1-x)}TiO_3$ Thin Films for Active Microwave Applications
J. Horwitz et al;
Ferroelectric Phase Shifters and Their Use in Microwave Phased Array Antennas
R. Babbitt et al;
Barium Strontium Titanate and Nonferroelectric Oxide Ceramic Composites for Use in Phased Array Antennas
L.C. Sangupta et al;
AC Conductivity and Dielectric Permittivity of TGS and UREA Doped TGS Crystals at Microwave Frequency
S.C. Mathur et al;

G. PYROELECTRIC DEVICES AND APPLICATIONS

Pyroelectric Thin Film Sensors and Arrays Based on P(VDF/TrFE)
I.N. Neumann et al;
Pyroelectric Thin Films for Device Applications
A. Kanduser et al;
A Thin Film Pyroelectric Detector
A. Bell et al;
Epitaxially Grown Pyroelectric Infrared Sensor Array for Human Body Detection
J.R. Choi et al;
Pyroelectric Characteristics of a Thin PZT (40/60) Film on a Platinum Film for Infrared Sensors
K.K. Deb et al;
Ferro-Piezoelectric Materials for Pyroelectric Receivers
L.A. Reznitchenko et al; □

UPCOMING MEETINGS

Thirteenth Conference on Crystal Growth
7 - 10 June 1994, Stanford Sierra Camp, Fallen Leaf Lake, California

Objectives

The American Association for Crystal Growth provides a forum for the presentation and discussion of both traditional, completed research and work in progress. The conference provides a relaxed environment that encourages interactions and discussions and a training ground where graduate students and young professionals can present their work.

Contact

Technical program co-chairs:

Ted F. Ciszek, National Renewable Energy Lab, 1617 Cole Blvd., Golden, CO 80401, Phone (303) 231-1769, Fax (303) 231-1271

Edith Bourret, Center for Advanced Materials, Lawrence Berkeley Laboratory, One Cyclotron Road, MS 2-200, Berkeley, CA 94720, Phone (510) 486-5553, Fax (510) 486-5530

Registration

Deadline: 1 May 1994

Local arrangements chairman: **H.M. Olsen**, Hughes Research Labs, 3011 Malibu Canyon Road, MS RL 63, Malibu, CA 90265, Phone (310) 317-5927, Fax (310) 317-5840

Fifth Russian-Japanese Symposium on Ferroelectricity (RJSF-5)
23 - 27 August 1994, Moscow

About 100 specialists, among them 30 Japanese scientists, are expected to attend the RJSF-5.

Sponsors

Moscow State University
Committee on Higher Education of the Russian Federation
Russian Academy of Sciences

Organizers

Honorary chairmen: K.S. Alexandrov, L.A. Shuvalov, S. Sawada, and J. Kobayashi
Chairmen: B.A. Strukov and Y. Ishibashi

Contact

A.I. Lebedev, Physics Department, Moscow State University, Moscow, 119899, Russia, Phone +(095)939-3917, Phone/Fax +(095) 939-1128, E-mail ail-f@scon.phys.msu.su

Attention: Conference Organizers

If you want current or back issues of the **Ferroelectricity Newsletter** *to distribute at your event, contact*
Hannah Liebmann
Phone (408) 649-5899 Fax (408) 655-3734

UPCOMING MEETINGS

Sixth International Seminar on Ferroelastic Physics
12 - 15 September 1994, Polytechnical Institute, Voronezh, Russia

Scope

The seminar will cover all aspects of processing, structure, properties, and applications of ferroelastic crystals. Both invited and contributed papers will be presented on fundamental and applied research on ferroelectrics, including, but not limited to, phase transitions and critical phenomena, lattice dynamics, lattice instabilities and soft modes, domains, domain boundaries, and imperfections, acoustic and ferroelastic properties, optical properties and radio spectroscopy, superionic conductivity in ferroelastics, ferroelasticity and superconductivity, modulated and incommensurate systems, disordered and glassy systems, as well as sensors, transducers, actuators, and other applications.

Organizers

Russian chairman: Lev A. Shuvalov, Crystallography Institute of the Russian Academy of Sciences

Vice chairman: Stanislav A. Gridnev, Voronezh Polytechnical Institute

Contact

Boris Prasolov, Voronezh Polytechnical Institute, Moskovsky Prospect 14, Voronezh 394711, Russia
Phone +(0732) 16-6647 or +(0732) 16-0628

The 1994 Fall Meeting of the Materials Research Society
28 November - 2 December 1994, Boston, MA

Symposium 12: Ferroelectric Thin Films IV

The ever growing sophistication of the ferroelectric thin-film community is marked by recent developments in electrode materials, scaling and process integration studies, novel deposition techniques, in-situ materials characterization, and increasingly complex device structures. Furthermore, understanding of the effects of interface phenomena, microstructural evolution, and the effects of atomic defects on ferroelectric and dielectric properties is rapidly evolving. The piezoelectric, electrooptic, dielectric, pyroelectric, and ferroelectric properties are being exploited in applications ranging from nonvolatile memories to micromotors. This symposium will present the latest developments in basic materials studies, device and materials process integration issues, growth of complex multicomponent ferroelectrics, and advanced characterization techniques.

Topics

Fundamental properties; structure-property-processing interrelationships; reliability issues: interfaces, defects, imperfections, and degradation phenomena; processing and integration; etching technologies; vapor-phase deposition technologies (chemical and physical); solution-based deposition technologies (sol-gel, MOD); pulsed laser deposition; ULSI/DRAM materials; nonvolatile memories; microsensors and actuators; bypass capacitors; electrooptic materials and devices; pyroelectric materials and devices; as well as novel materials and new processes.

Joint sessions are planned with Symposium C: *Structure and Properties of Interfaces in Ceramics,* and Symposium I1: *Materials for Smart Systems.*

Abstract Deadline

20 June 1994

Organizers

Seshu B. Desu, Department of Materials Science and Engineering, Virginia Tech, 203 Holden Hall, Blacksburg, VA, Phone (703) 231-6820, Fax (703) 231-8919

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R. Ramesh, Bellcore, 331 Newman Springs Road, Red Bank, NJ 07701, Phone (908) 758-3126, Fax (908) 758-4372, E-mail ramesh1@troy.bellcore.com

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CALENDAR OF EVENTS 1994

Apr 4-8 24 - 28	• MRS 1994 Spring Meeting, San Francisco, CA (see *F. Newsletter* Vol. 1, No. 4, p. 6) • American Ceramics Society Meeting, Indianapolis, IN
May 22-27	• Symposium on Silicon Nitride and Silicon Dioxide Thin Insulating Films, San Francisco (see *F. Newsletter* Vol. 2, No. 1, p. 9)
June 7-10	• 13th Conference on Crystal Growth, Stanford Sierra Camp, California (see p. 10)
Aug 7-10 9-11 23-27 29- Sep 2 20- Sep 10	• 9th IEEE Internat. Symposium on the Applications of Ferroelectrics, University Park, PA (see *F. Newsletter* Vol. 1, No. 4, p. 8) • 3rd Asian Regional Seminar on Microelectronics and Information Technology, Bangkok (see *F. Newsletter* Vol. 2, No.1, p. 10) • 5th Russian-Japanese Symposium on Ferroelectricity, Moscow (see p.10) • Internat. Symposium on Ferro- and Piezoelectric Materials and Their Application '94, Moscow (see *F. Newsletter* Vol. 2, No. 1, p. 10) • International Exhibition on Ferro- and Piezotechnics '94, Moscow (see *F. Newsletter* Vol. 2, No. 1, p. 10)
Sep 5-7 6-9 7-9 12-15	• Electroceramics IV, Aachen, Germany (see *F. Newsletter* Vol. 1, No. 4, p. 9) • 3rd International Symposium on Domain Structure of Ferroelectrics and Related Materials (ISFD-3), Zakopane, Poland (see *F. Newsletter* Vol. 1, No. 4, p. 10) • 8th International Symposium on Electrets (ISE 8), Paris (see *F. Newsletter* Vol. 2, No. 1, p. 10) • 6th Internat'l Seminar on Ferroelastic Physics, Voronezh, Russia (see p. 11)
Nov 21-24 28-Dec 2	• 2nd Pacific Rim Workshop on Ferroelectric Applications, Melbourne, Australia (see *F. Newsletter* Vol. 2, No. 1, p. 10) • MRS 1994 Fall Meeting, Boston (see p. 11)
	1995
Jul 4-8	• 8th European Meeting on Ferroelectricity, University of Nijmegen, The Netherlands. For information contact Mrs. Rina Vos, Secretariat EMF8, Institute for Theoretical Physics, University of Nijmegen, Toernooiveld, 6525 ED Nijmegen, The Netherlands

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